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**William A. Fowler**

Charles A. Barnes

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a joint appointment at Penn State's Applied Research Laboratory.

**David E. Carlson**, vice president of the thin film division of Solarex, an Amoco subsidiary located in Newtown, Pennsylvania, has been chosen

to receive the 1995 Karl W. Boer Solar Energy Medal of Merit from the University of Delaware. He is being honored for his "discovery and development of thin film amorphous silicon solar cells for the conversion of sunlight into electricity."

## OBITUARIES

### William A. Fowler

**W**illiam A. Fowler, Institute Professor of Physics Emeritus at the California Institute of Technology, died on 14 March 1995 in Pasadena, California, at the age of 83. In winning the 1983 Nobel Prize in Physics, with Subrahmanyan Chandrasekhar, Fowler was cited for his theoretical and experimental studies of the nuclear reactions of importance in the formation of the chemical elements in the universe. For most of his scientific career, he was the acknowledged leader of the research area now called nuclear astrophysics.

Fowler graduated in engineering physics from Ohio State University in 1933 and received his PhD from Caltech in 1936, working with Charles C. Lauritsen on proton- and deuteron-induced radioactive nuclei. He spent his entire scientific career at Caltech, where he was named Institute Professor Emeritus in 1982. Fowler's work in nuclear physics began in 1933, shortly after the conversion of one of Lauritsen's "super-voltage" x-ray generators to positive-ion operation, which was prompted by the 1932 report by John Cockcroft and Ernest Walton that nuclear reactions could occur at particle energies as low as a few hundred keV.

In 1937-39 Hans Bethe, in the United States, and Carl Friedrich von Weizsäcker, in Germany, independently proposed a mechanism for supplying the energy to keep stars shining for billions of years—the C-N cycle of reactions that employs carbon and nitrogen isotopes as catalysts to transmute four protons to a helium nucleus (plus two positrons and two neutrinos). In addition, Bethe and Charles Critchfield proposed the proton-proton chain of reactions that can accomplish the same result starting from hydrogen alone.

The first reaction in the proposed C-N cycle, the radiative capture of protons by  $^{12}\text{C}$  to form  $^{13}\text{N}$ , was one of the first nuclear reactions studied at Caltech in 1933, and the Kellogg Laboratory's ongoing study of nuclear reactions involving light nuclei was exactly what was required to make a



WILLIAM A. FOWLER

quantitative test of the proposed energy-production processes. This capability and the frequent exchange of ideas between astronomers from the Mount Wilson Observatory and physicists at Caltech convinced Fowler and his associates of the importance of concentrating on such studies. A pressurized Van de Graaff accelerator was designed by Thomas Lauritsen and Fowler and built for this work, but the outbreak of World War II in Europe intervened just as the new accelerator came into operation.

In 1940 Fowler and most of the Kellogg Laboratory group joined the effort at the Carnegie Institution's Department of Terrestrial Magnetism, in Washington, DC, to develop the proximity fuze. They returned to Caltech in 1941 to develop solid-fueled rockets, a project that produced a wide variety of rockets, many of which played an important role in the war; the project was transferred to the US Navy in 1944.

At the end of the war Fowler and his colleagues returned to nuclear physics, aiming a major fraction of the research at the study of nuclear astrophysics. Strong encouragement came from Ira Bowen, director of the Mount Wilson and Palomar Observatories, and from Jesse L. Greenstein, who led a growing program in astron-



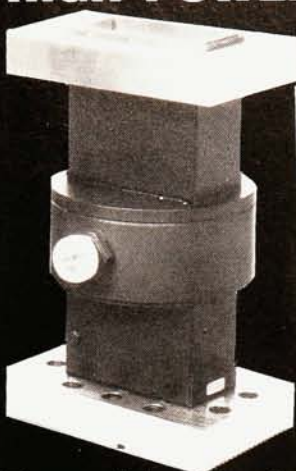
omy at Caltech. Fowler and his associates first studied the reactions of the C-N cycle and developed better techniques to carry the necessary extrapolations to the lower energies relevant in stellar cores. As it became clear that stars with masses up to about 1.2 times that of our Sun derive their main-sequence energy from the proton-proton chain instead of the C-N cycle, the p-p reactions were also studied.

The laboratory measurements were then extended to the reactions that build carbon and oxygen from the helium nuclei ( $\alpha$  particles) created in stellar cores. In 1951 Edwin Salpeter of Cornell University suggested that three  $\alpha$  particles could form  $^{12}\text{C}$  via the very short-lived intermediate nucleus  $^8\text{Be}$ . However, early in 1953 Fred Hoyle pointed out that this mechanism would not be a viable way to make the observed abundance of carbon unless there was an excited state of  $^{12}\text{C}$  just above the  $^8\text{Be} + \alpha$  threshold that would serve as a resonance. Hoyle, then a visitor at Caltech, proposed to Fowler and his colleagues that a search be made for such a state, and the predicted state was found within a few days by Ward Whaling and his Kellogg Laboratory associates. This discovery decisively removed any lingering concerns that Fowler or his colleagues might have had about the feasibility of building elements in stars.

Fowler spent his sabbatical year of 1954-55 in Cambridge, where he worked with Geoffrey and Margaret Burbidge and with Hoyle. He persuaded the three of them to come to the Kellogg Laboratory, and in 1957 the Burbidges, Fowler and Hoyle published their seminal paper, "Synthesis of the Elements in Stars," which quickly became known as "B<sup>2</sup>FH." In this work the building of elements up to the mass region  $A = 60$  was attributed to charged-particle reactions, and the heavier elements were mainly the product of successive neutron captures, some on a slow time scale (the s-process) and others on a rapid time scale (the r-process). Alastair Cameron, then at the Atomic Energy of Canada Laboratory in Chalk River, Canada, independently developed a similar scenario at about the same time.

In 1958 Harry Holmgren and R. L. Johnson, then at the US Naval Research Laboratory, reported that the cross section for producing  $^7\text{Be}$  by the radiative capture of  $\alpha$  particles by  $^3\text{He}$  was about 200 times larger than previously estimated. This change would increase the production of  $^8\text{B}$  in the solar interior by the same factor. Since  $^8\text{B}$  is a relatively high-

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### John T. Tate International Medal

Roland W. Schmitt, Chair of the Governing Board of the American Institute of Physics, has announced his appointment of a Selection Committee to recommend a candidate for the **John T. Tate International Medal for Distinguished Service to the Profession of Physics**. Members of the Selection Committee are Hans Frauenfelder, E. Leonard Jossem, and Burton Richter.

The John T. Tate Medal was established by the American Institute of Physics to recognize distinguished service to physics on an international level. The Award is intended primarily for foreign nationals. It is awarded at intervals of about three to five years and will be accompanied by a certificate and cash award of \$5000.

The award is for service to the profession of physics rather than for research accomplishment. Services that enhance international understanding through physics are considered to be of primary importance. Examples might be the establishment or improvement of publications, the promotion or administration of joint research projects, or the operation of unusually successful international conferences. A citation on the accompanying certificate will state the particular service for which the award is made.

The recipient is chosen by the Governing Board of the Institute on the recommendation of a selection committee appointed for the purpose.

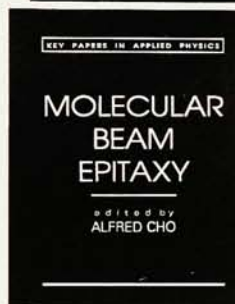
The medalist is expected to receive the award in person and travel expense is reimbursed by the Institute.

Recent recipients of this Medal include Edoardo Amaldi (1989) and Roald Sagdeev (1993).

Recommendations of candidates to be considered by the Selection Committee should be forwarded to a member of the committee, or to Roderick M. Grant, Secretary, re: Tate Award Selection Committee, American Institute of Physics, One Physics Ellipse, College Park, MD 20740-3843. The deadline for receipt of recommendations is **1 November 1995**.



# Alfred Y. Cho



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energy positron and neutrino emitter, Fowler and Cameron, independently and almost immediately, pointed out that if the temperature of the Sun were high enough, it might be possible to detect  $^8\text{B}$  solar neutrinos in the  $^{37}\text{Cl}$  radiochemical neutrino detector developed in the early 1950s by Raymond Davis. Fowler encouraged the joint publication in 1964 of papers by John Bahcall (then at the Kellogg Laboratory) and Davis that showed that the detection of the theoretically expected flux of solar neutrinos was possible. For the rest of his life Fowler was an enthusiastic supporter of solar neutrino research.

In 1960 Hoyle and Fowler formulated what is now the standard paradigm for supernova mechanisms, attributing Type I supernovae to the thermonuclear explosion of low-mass degenerate stars and Type II supernovae to the collapse of the iron cores formed in massive stars. Also in 1960 Fowler and Hoyle extended the results of  $\text{B}^2\text{FH}$  to dating the synthesis of the chemical elements from the abundances of the isotopes of the radioactive nuclei uranium and thorium and their transuranic ancestors, all made in the  $r$ -process. Fowler continued to update this cosmochronology as observations improved over the years.

In 1967 Fowler and Hoyle, with Robert V. Wagoner, presented one of the most comprehensive, and one of the most referenced, studies of both the dynamics of the expansion of the universe (known as the Big Bang) and the nucleosynthesis that would result. That same year, motivated by the rapidly growing inventory of experimental results from the Kellogg and other laboratories, Fowler, with Georgeanne Caughlan and Barbara Zimmerman, published the first of a series of reviews evaluating the available experimental nuclear data and recommending best values for the nuclear reaction rates needed in astrophysical calculations. This series of reviews continued with a variety of coauthors until 1988 and provided the nuclear physics foundation for most modern studies of stellar evolution and nucleosynthesis.

Although only a few of Fowler's papers can be listed here, Willy Fowler, as he was known worldwide, was a prolific researcher and author, and he collaborated with a remarkably wide circle of associates and students. He was always generous in sharing credit, and he helped launch many careers. He freely gave his time to numerous scientific, academic and governmental organizations. He had an unusual ability to bring people together and infuse them with his en-

thusiasm and sense of fun. Whether he was discussing astrophysics, steam-powered trains, wind-bagging in the California surf or the prospects of the Pittsburgh Pirates baseball team, his *joie de vivre* never failed to brighten the world around him.

CHARLES A. BARNES

California Institute of Technology  
Pasadena, California

## Hannes Alfvén

Hannes Alfvén, Nobel laureate for physics and an outstanding pioneer in plasma physics and astrophysics, died on 2 April 1995 at his home in Djursholm, Sweden.

Alfvén was born on 30 May 1908 in Norrköping, Sweden. After university studies in Uppsala he presented his doctoral thesis at the age of 26. At 32 he was appointed professor of electromagnetic theory and electric measurements at the Royal Institute of Technology, Stockholm. His vigorous scientific activity led to the creation of a number of new professorships and departments. The three departments that most directly trace their origin to his work now form a separate entity within the institute, the Alfvén Laboratory, founded in 1990.

In 1967 Alfvén accepted a professorship at the University of California, San Diego, but every year from then on he spent the time "from the vernal equinox until the autumnal equinox" in Sweden, in very active scientific interaction with his colleagues at the Royal Institute. He continued this migration as well as his vigorous scientific activity long after his formal retirement in 1973.

All of Alfvén's scientific work reveals a profound physical insight that allowed him to extract results of great importance and generality from specific problems. He also got a fresh perspective by approaching astrophysical problems from an electromagnetic point of view.

In 1933, as a graduate student, Alfvén developed a theory of the origin of cosmic radiation. This work led him to propose in 1937 the existence of a Galactic magnetic field. This proposal was generally dismissed, and only much later was it confirmed that the Galactic magnetic field indeed exists.

Alfvén's best-known discovery, of what we now call Alfvén waves, is in many ways typical of his approach. It grew out of a specific problem, namely that of sunspots and the sunspot cycle, but the waves he discovered have proven to be of fundamental importance in all of plasma physics. At